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PROCEEDINGS OF THE AMERICAN FOUNDRYMEN'S ASSOCIATION.

MEMORANDUM ON CAST IRON UNDER THE TRANSVERSE TEST.*

By DR. R. MOLDENKE.

In the transverse tests made with Sets A, B and C, the distance between the supports for the bars was always taken at 12″, the bars themselves being but 2″ longer. This distance was selected after a careful consideration of the subject. It is a convenient length for such tests, the foot moreover is also a unit of distance; the bars can be cast vertically without trouble, and their weight is not excessive.

As the bars selected for the transverse test in a full set number 128, one can readily imagine the difficulties which would be encountered in attempting to get them three or even five feet long. A bar four inches square and five feet long would be a cumbersome thing to test.

An important consideration influenced the adoption of the foot as a standard distance between supports in these tests, and that is the well known fact that with a given testing speed, the longer the bar the less searching the test. A five foot cast iron

* To form appendix "C" to the final report of the American Foundrymen's Association committee on standardizing the testing of cast iron. The previous reports of this committee will be found in the Journal of the Association of June, 1899.

bar will support a very much greater load before breaking if this is applied gradually and without the least jar than it will if the load is put on quickly and with shocks. In the latter case the bar simply has no time to adjust itself to rapidly changing conditions which may require twice as much resisting power on its part than it needs under the static load, and hence it breaks much before it would have done, had it been able to yield slowly as the pressure increased. On the other hand it is also known that with perfectly steady loads the quicker they are applied the higher the results, though this is more marked in the elastic materials than in cast iron. With our testing machines as usually constructed the question of speed is such that it is better to test a short bar slow than a long one fast. Again the service conditions for cast iron are of a kind that make it desirable to know how it will behave under quickly applied loads, castings usually failing under shock. To keep the transverse test separate from the impact test (with its special feature of absorbing energy for deformation purposes) and yet take into account this service requirement means a short bar tested quickly.

It was, therefore, deemed wise to obtain some information on the influence of the length of the bar upon the results from cross breaking tests. To make the data secured comparable it was necessary to adopt a system of casting which would bring the required number of test bars under identical foundry conditions. This was accomplished by making six patterns of a two-inch square bar 16 inches long. Each pattern was provided with a conical pouring gate at one end, all six being molded gate end up in an iron flask in such a way that the gates were in the bottom of a trough for flushing in a large quantity of metal quickly. The molds were of dry sand and the cast was repeated with six different heats. In this way a series of bars was obtained in which not only six different tests could be made on material exactly alike, but the same tests could be repeated five times on different heats to obtain good working averages.

For the preparation of this series of test bars the committee is indebted to the generosity of the Frank-Kneeland Machine

Co., of Pittsburg, Pa., who went to considerable trouble in making patterns and castings to exactly fulfill the requirements of the case. The tests themselves were carried out as follows: With the same testing speed the six bars of each set were broken transversely with a distance between supports of 6, 8, 10, 12, 14 and 16 inches. The range from 6 to 16 inches is a fairly wide one, and together with the deflections noted gives a good basis for comparisons.

TABLE 1.

Transverse Test.

Bars 2"x2"x16", cast 3/8/'99—Heavy machinery mixture.

No.	Actual Cross Section. Depth.	Actual Cross Section. Width.	Supports. Apart.	Breaking Strain—lbs.	Modulus of Rupture per sq. in.—lbs.	Deflection.
848	1.96"	2.02"	6"	33,570	38,930	.063"
849	1.96"	2.00"	8"	24,310	37,970	.068"
850	1.98"	1.98"	10"	18,150	35,070	.081"
851	2.00"	2.00"	12"	15,880	35,730	.081"
852	2.00"	1.98"	14"	14,230	37,730	.100"
853	2.00"	1.98"	16"	11,980	36,300	.102"

TABLE 2.

Transverse Test.

Bars 2"x2"x16", cast 3/9/'99—Heavy machinery mixture.

No.	Actual Cross Section. Depth.	Actual Cross Section. Width.	Supports. Apart.	Breaking Strain—lbs.	Modulus of Rupture per sq. in.—lbs.	Deflection.
854	1.96"	2.04"	6"	40,980	47,060	.063"
855	1.96"	2.00"	8"	26,380	41,200	.069"
856	1.98"	1.97"	10"	19,860	38,570	.062"
857	2.00"	2.00"	12"	17,250	38,810	.079"
858	2.00"	1.99"	14"	14,770	38,960	.082"
859	1.98"	2.04"	16"	11,100	33,310	.099"

TABLE 3.

Transverse Test.

Bars 2"x2"x16", cast 3/10/'99—Heavy machinery mixture.

No.	Actual Cross Section. Depth.	Width.	Supports. Apart.	Breaking Strain—lbs.	Modulus of Rupture per sq. in.—lbs.	Deflec-tion.
860	1.96"	2.01"	6"	28,920	33,710	.057"
861	1.96"	2.01"	8"	22,700	35,280	.068"
862	1.98"	2.01"	10"	17,480	33,270	.046"
863	2.00"	1.96"	12"	15,400	35,370	.072"
864	1.99"	1.96"	14"	10,120	27,380	.092"
865	2.02"	1.97"	16"	10,880	32,480	.094"

TABLE 4.

Transverse Test.

Bars 2"x2"x16", cast 3/28/'99—Heavy machinery mixture.

No.	Actual Cross Section. Depth.	Width.	Supports. Apart.	Breaking Strain—lbs.	Modulus of Rupture per sq. in.—lbs.	Deflec-tion.
866	1.96"	2.02"	6"	35,240	40,870	.051"
867	1.96"	1.99"	8"	26,760	42,010	.071"
868	1.98"	2.00"	10"	19,860	37,990	.051"
869	2.00 "	1.99"	12"	18,200	41,150	.088"
870	2.00"	1.96"	14"	14,280	38,250	.079"
871	1.98"	1.96"	16"	10,950	34,200	.088"

TABLE 5.

Transverse Test.

Bars 2"x2"x16", cast 3/31/'99—Heavy machinery mixture.

No.	Actual Cross Section. Depth.	Width.	Supports. Apart.	Breaking Strain—lbs.	Modulus of Rupture per sq. in.—lbs.	Deflec-tion.
872	1.96"	1.99"	6"	30,440	35,840	.052"
873	1.96"	1.98"	8"	24,770	39,080	.065"
874	1.98"	2.00"	10"	14,820	28,350	.069"
875	2.00"	1.99"	12"	13,820	31,250	.073"
876	1.96"	1.96"	14"	11,710	32,660	.103"
877	1.96"	1.96"	16"	9,210	29,360	.082"

TABLE 6.

Transverse Test.

Bars 2"x2"x16", cast 4/5/'99—Heavy machinery mixture.

No.	Actual Cross Section. Depth.	Width.	Supports. Apart.	Breaking Strain—lbs.	Modulus of Rupture per sq. in.—lbs.	Deflection.
878	1.98"	2.04"	6"	38,760	43,620	.092"
879	1.98"	2.02"	8"	25,650	38,870	.078"
880	2.01"	2.02"	10"	22,160	40,730	.074"
881	2.00"	2.02"	12"	17,750	39,540	.086"
882	2.00"	2.01"	14"	16,240	42,420	.108"
883	2.02"	2.04"	16"	14,090	40,630	.113"

Tables 1 to 6 give the results in detail. Averaging the results we have the following:

TABLE 7.

Bars 2"x2"x16"—Heavy machinery mixture.

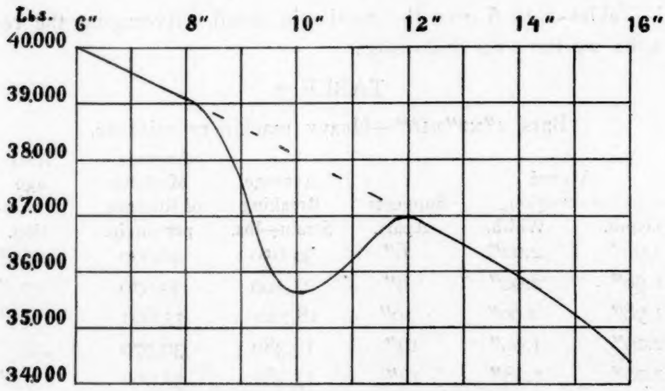
Averge Cross Section. Depth.	Width.	Supports Apart.	Average Breaking Strain—lbs.	Average Modulus of Rupture per sq. in.	Average Deflection.
1.96"	2.02"	6"	34,650	40,000	.063"
1.96"	2.00"	8"	25,100	39,070	.070"
1.98"	2.00"	10"	18,720	35,660	.064"
2.00"	1.99"	12"	16,380	36,970	.080"
2.00"	1.98"	14"	13,560	35,900	.094"
1.99"	1.99"	16"	11,370	34,380	.096"

Representing the average modulus of rupture per square inch in the above table graphically, we obtain the very interesting curve shown on page 82.

But for the 10" point the curve would slope downward nearly uniformly. That the break is correct is shown by the same tendency in the curves plotted for each table separately. Whether this break would exist in that place or at all in bars of other cross sections must be left unanswered here. Another interesting speculation would be what influence would result from a testing speed perfectly uniform throughout each test, but increasing as the distance between supports increases (let us say

so that for a given time the quotient of the length divided by the deflection remains constant).

It is possible that with a constant testing speed there is a point in transverse tests of cast iron at which the increase or decrease of a fixed ratio between the depth of the bar and the distance between supports (10″ divided by 2″, or 5 in this case) may mean a change from one set of conditions to another. If this be the case it is evident that the matter will be more serious in heavy bars than in light ones, and that with 10 inches for the 2-inch square or heaviest likely test bar, it would be very much less for say a half inch bar. Now in testing the iron it would



AVERAGE CURVE OF SIX SETS OF TESTS.

be unsafe to accept everything up to this distance of 10″, and beyond 10″ the results would gradually lose in value the further they went. Therefore the 12-inch distance between supports would seem the safest and yet smallest distance to adopt with bars approaching a fairly heavy cross section, and would very likely be just as acceptable in the case of the smaller ones.

For our purposes, however, it is sufficient that five points out of six are in line, and that therefore the ordinary formulas used in calculating the cross breaking strength of beams are not only incorrect for cast iron, on account of the chemical differences in the iron itself when in different cross sections, but that

with the cross sections identical the distancee between the supports must be specially provided for by suitable constants in whatever formulae may be developed. As seen from the illustration on the preceding page, the doubling of the distance between supports means a drop in the modulus of rupture per square inch of the same iron in the same sized bar of nearly 10 per cent.

Another point of interest is a development from this series of tests. The resilence of the material or its shock resisting power is often calculated from the transverse test by dividing the half product of the breaking load with the deflection by the weight of the bar between supports, the result being the shock resisting modulus in inch pounds per pound of metal. From table 7 we have

Distance between supports...	6″	8″	10″	12″	14″	16″
Modulus	176	107	58	53	44	33

or a steady progression downward. As the bars of each set were exactly alike in material and had the same dimensions, their shock resisting quality should certainly be the same, yet the formula regularly employed makes the first result over five times as good as the last. That the shock resisting moduli will be lower for thick sections than for thin ones is known, but that so great a discrepancy should exist with the same dimensioned bars when tested as indicated, is surprising.

But one point remains. All the bars were cast vertical. As in the case of casting bars flat, there is a noticeable difference in their strength when tested bottom or top side up, so with the vertical bars there is a feeling that the lower portion might give different results from the upper. The broken pieces of the above tests were therefore again tested transversely and the results noted in Table 8. In this case the pieces were all broken transversely with supports 6″ apart. While the bars have already been strained beyond their elastic limit (at one end) and the results below cannot therefore be accepted as perfectly reliable, yet the comparison is of sufficient value to be worth recording:

TABLE 8.

Test No.	Bar No.	Breaking Strength. Upper Half.	Lower Half.
884-885	848	34,400	33,940
886-887	849	34,260	33,410
888-889	850	33,910	33,340
890-891	851	34,610	36,540
892-893	852	34,450	34,000
894-895	853	34,940	34,620
896-897	854	43,670	44,100
898-899	855	38,260	40,450
900-901	856	36,960	37,840
902-903	857	37,020	39,320
904-905	858	38,840	38,200
906-907	859	36,540	36,310
908-909	860	30,760	32,480
910-911	861	31,100	30,900
912-913	862	31,850	29,780
914-915	863	32,450	32,420
916-917	864	30,660	30,890
918-919	865	31,750	31,850
920-921	866	37,400	37,550
922-923	867	38,980	38,500
924-925	868	39,060	41,450
926-927	869	42,650	35,950
928-929	870	38,440	38,960
930-931	871	35,860	35,510
932-933	872	31,800	32,350
934-935	873	34,730	32,650
936-937	874	33,800	33,720
938-939	875	31,610	31,060
940-941	876	32,930	30,100
942-943	877	35,540	35,070
944-945	878	42,250	38,770
946-947	879	41,320	39,110
948-949	880	43,190	40,060
950-951	881	40,640	39,710
952-953	882	46,270	46,820
954-955	883	43,440	44,800

The average pressure required to break the upper halves of the 36 bars is therefore 36,560 lbs., compared with 36,180 lbs. for the lower, a result sufficiently close to be quite satisfactory.

The several points brought out in this study may be of interest to those who care to pursue the subject further, the scope of the work, so far as the committee is concerned, being filled in obtaining the information relative to the use of 12 inches as the distance between supports of bars tested transversely.

IMPACT TESTS FOR CASTINGS AND TEST BARS.

At the Pittsburg meeting of the American Section of the International Association for Testing Materials Thos. D. West presented the following paper on "Impact Tests for Castings and Test Bars:"

"In replying to Prof. W. K. Hatt's request for views and experiences on impact tests, for presentation at this meeting, the writer would state that it is practical to apply it to castings, after the principle exhibited in testing car wheels. He considers the impact test one that will fairly denote what may be expected of such castings when subjected to shocks or slight changes in their temperatures.

"Impact tests on the side of test bars are of no value in indicating what may be expected of castings, unless it is known by experience with castings made from the same mixture, what they will withstand, and a record is kept of the contraction and analyses of the mixtures. This necessity of first knowing what a special form of casting will stand in actual service, makes impact tests on test bars a very roundabout way of obtaining knowledge and is like putting the cart before the horse, as with most all other forms of tests we can accept the records of test specimens as an index to what may be expected from irons or mixtures before castings are made or tested.

"Some have thought that if test bars proved strong under impact tests, castings made from the same iron would resist shocks or jars to an equal degree. The ability of castings to resist shocks is as a rule as dependent upon their form and proportion as upon the grade of iron from which they are made. In fact, castings can be so designed as to prove stronger under impact tests or use, though made with irons showing the weakest results in test bars. This is due, first, to the fact that strong or hard irons possess a greater contraction than weak or soft irons, and, second, to the fact that light bodies will contract more than heavy ones, made from the same iron. These two factors work in opposite directions in annulling what may be affirmed by blows

delivered on the side of test bars. To illustrate this point, the writer would call attention to experiments which he conducted to find the difference in the contraction of two pieces of casting 14 feet long, one being ½x2 inches and the other 4x9 inches in their cross section, both pieces being poured of the same iron and at the same time. This experiment gave a contraction of 1¾ inches for the light body and ⅞ inch for the heavy one, showing that the light body contracted as much again as the heavy one.

"Taking into consideration the fact that light parts of all castings possess a greater contraction than their heavy parts, were they left free to act, as proven by the tests cited in the above paragraph, it will be seen that there must exist an internal strain in all such castings. Then again, when we consider that in connection with the subject of internal strains, strong or hard iron possesses a greater contraction than soft or weak iron, we are forcibly brought to see why irons that may show exceptionally strong results in test bars would cause a casting to crack from the least jar or change in its temperature. Further, as soft or weak irons possess less contraction and hence cause less internal strains in castings, we may often find they will stand much rougher usage than the test bars would indicate. The writer believes that a study of these suggestions will direct thought to what is practical in utilizing impact tests on castings and test bars."

A REVIEW OF THE FOUNDRY LITERATURE OF THE MONTH.

IRON AGE.

Referring to the action of the Iron Molders' Union at its Indianapolis convention in advising its members to accept work upon molding machines, this journal says, in its issue of August 10:

Sensible action was taken at their recent convention at Indianapolis by the Iron Molders' Union of North America. All members were advised to accept work on molding machines and bring out their highest possibilities. This is a recognition of progress which is worthy of American workmen. Instead of fighting improvements in their methods, as short-sighted men have been known to do, the molders may now be relied upon to co-operate in the introduction of labor saving and cost reducing devices. The introduction of molding machinery has been making great progress of late. The rapid growth of large industries, involving the use of castings of the same pattern in greatly increased quantities, has caused foundry managers to study methods of enlarging output without making vast additions to floor space. This has been accomplished by the adoption of molding machines in connection with continuous melting, which has completely revolutionized the time honored customs of the trade in numerous foundries, and will undoubtedly do so in many more in the near future. Such close watch is kept on the movements of competitors that the introduction of such innovations in one establishment is certain to be shortly followed in others making the same class of product. As unskilled workmen can soon be taught how to operate molding machines, it may seem that the Iron Molders' Union have simply bowed to the inevitable in deciding not to oppose their use.

Nevertheless, it must be conceded that the organized molders could create a great deal of trouble and seriously interfere with the smooth operation of machine using foundries if they were decidedly hostile to the introduction of molding machines. They

have themselves settled a question which might have proved exceedingly vexatious, and for this they deserve commendation.

The field of application for machinery of this character is gradually but surely extending. It was at first supposed that molding machines were only adapted to a limited range of work, covering castings of quite moderate size, simple in form and not very thin. But success in the lines first followed led to experiments in more difficult patterns and in larger pieces, so that at the present time quite a wide range of work is turned out by these machines. They have not yet been generally introduced in stove foundries. The causes for this were admirably set forth in the paper recently read by Abram C. Mott, of Philadelphia, before the convention of the National Stove Manufacturers at Cincinnati. He came to the conclusion that unless at least 60 full consecutive days' work could be found for a machine on one pattern it would not be of any economic value whatsoever. His conclusion was controverted by Lazard Kahn, of Cincinnati, who instanced certain classes of work in stove molding on which machines could be employed economically. Since then some investigation in this line has been made by stove manufacturers whose interest has been awakened, and it appears quite probable that ere long the stove trade may be able to point to results accomplished in stove plate molding by machinery which had been deemed utterly impracticable by men of the highest technical standing among stove makers. Possibly the general use of molding machines in that trade would have the effect of standardizing many parts in every stove foundry, in order to increase output and reduce cost, which would be a radical departure from existing practice. But as this has been brought about by force of circumstances in other lines, it may eventually take place in the stove trade. The fact seems to be established, however, and the action of the Iron Molders' Union confirms it, that machine molding is destined to become a more conspicuous feature of general foundry practice.

AMERICAN MACHINIST.

In the issue of Aug. 10 R. D. Moore has an article on "Producing Straight Castings and Methods of Straightening," in which he says:

To be thoroughly equipped for handling all the warping castings that come to a jobbing foundry requires a clear understanding of the causes by which warps are produced and the several devices for correcting them; that is, it should be known beforehand where the warp will be, and the proper treatment for each case. Straightening by bending the pattern in the sand in an opposite direction is one of the most simple methods and easy to understand, but it is only applicable to a very limited number of cases, such as long, slender lathe beds, where the pattern has only moderate stiffness to overcome.

One example of castings which may be kept straight by stripping is the lintel box, which is a good sample of warping casting, and one easily treated, as it has the heavy side on top. I have handled very successfully all sizes up to 40 feet long and weighing nearly five tons. Although the long sizes have lately been largely superseded by the more reliable, made-up steel article, these still serve to illustrate one straightening treatment. A 12-foot lintel of this form would have a top plate, as molded, say $1\frac{1}{4}$ inches thickness, the sides $\frac{7}{8}$ inch tapered down for draft to $\frac{1}{2}$ inch at the bottom. Such a casting would cool very irregularly as to time. The top side, when the cope was removed, would be a bright red, while the thin edges at the bottom would be a very dull red, and the casting still straight. Such a combination, with irregular shrinkage to follow, would promise a crooked casting; that is, the top side, having the most shrinkage to occur, would become too short, and would be concave a half-inch or more, or contrary to mere shrinkage set. It presents a simple case. The metal has been distorted by shrinking irregularly under confinement, and the remedy lies in stretching the top side by stripping two or three sections near the middle, or about 5 feet of its length altogether. Cooling the top, if it cannot lift the ends, is a stretching process on the top plate. Weighting down the ends would be harmless in this case, and might be needed, as a lift of the ends would defeat the stretching of the top plate.

A case where heating kept the casting straight occurred with

an 8-inch fluted building column 12 feet long, in which, on account of the anchor plates being too thin the chaplets had sunk into the loam core, allowing the core to rise, promising a crooked casting. The top was stripped nearly bare and 100 pounds of dull melted iron poured, a little at a time, all over the top, then all was well covered with sand. On examining it later the color of top and bottom was found about equal, and the casting in the morning proved to be straight, a more valuable quality in a column than perfect equality of metal; and this treatment reduced the permanent shrinkage strain by insuring an equal time of cooling. With a stiff cast "barrel," the core, at the exact center, probably raised ¼ inch, leaving ½ inch on top and 1 inch on bottom, instead of ¾ inch all around.

There are a few cases of long, slender castings showing objectionable warping on account of unequal cooling, where the warping can be corrected very easily, and with more certainty than by any other process, through simply bending the flask in an opposite direction from that taken by the casting in warping. The bend should be made soon after pouring, or while the metal is still a high red, so that it will yield easily and receive the true set without fracture. My first experiment with this method was on stationary engine beds, the casting forming one side of a bed for 16 and 18-inch cylinders, with 4-foot stroke, and used quite extensively for driving Louisiana sugar mills. They were of the bold-paneled, ogee-molding style, 20 inches wide, 8 inches deep, and 22 feet long, and were cast with the face down, the inside being formed of green-sand cores hung in the cope with two screws in the wrought-iron core skeleton, the pattern being solid. With green-sand cores there will be considerable strain and a thickening at the bottom, which will increase the warp. These castings warped according to rule; that is, the ends sprung down 1¾ inches. Soon after pouring I set a heavy bar of iron under the bottom board, two or three feet from the end of the flask; then hooking on two sling hooks, hoisted the flask end until the end batten showed a lift of fully 1¾ inches from its bed. Plenty of large wedges were then driven under several of the battens for a

firm support. The crane was then taken off and the other end of flask was treated in the same way. The flask in this case was of iron, but, being long and relatively slender, it bent under its weight with a very regular curve, producing a very true casting every way. These engine bed castings, thus treated, averaged between 36 and 50 a year for a long term of years, and not costing a cent for treatment, the device proved valuable.

These bed castings had formerly been straightened by the machinists, who fitted them, under the direction of a very incompetent manager, by reheating with a wood fire and weighting down. They blundered in many ways, and obtained an imperfect job in every attempt. They persisted, against repeated advice, in resting the casting on one center bearing, and in heating a very short section only, compelling a few inches of the length of it to stand an excessive amount of stretching, and almost invariably starting perceptible cracks, and kinking the top edges by excessive compression; that is, the top edge, as molded, but the bottom when straightened. There is no excuse for committing such violence on a few inches of length when we have 22 feet to act on, and worn-out flasks to slaughter. Besides, the longer the bend, the nearer the curved line is converted into a straight line.

Straightening by fire will be found to be one of the most delicate and difficult feats for the manipulator of castings. One of the most universal faults observed is the habit of piling on an excessive load of weight before heating, thus often cracking the casting before the highest heat is reached; the weight necessary is often surprisingly small. After witnessing many of those imperfect jobs, I volunteered to try one, and succeeded well in the following manner: The bed was placed on two bearings, about 4 feet apart and 4 inches high. A rough wall of fire-brick or double grate bars was made, 8 or 10 inches from the casting, to check the draft and the escape of heat, also to confine the fire closer to the casting. A strong wood fire was then applied to fully 5 feet of the middle of the casting. Gage blocks were set under each end to bend the casting to, but they were not final, as

they should be adjusted when the bend is made. The heating may have raised or lowered the ends, and then the bend given would be out to that amount. To prevent the long ends from settling too soon, when heated, a lever was placed under each end and a bar or plank to sustain one-third to one-half of the projecting weight until the time came to adjust the gages and weight down. Such levers, carefully poised, will accommodate themselves to the heat bends, and not distort the casting beforehand.

In its commercial review of Aug. 17 the American Machinist quotes the experience of a certain buyer to show how difficult it is to obtain prompt shipments and place contracts which call for immediate delivery, as follows:

The experience of a manager of a machinery building concern the other day is of interest as showing the present condition of the market for some of the things needed in machine construction. This man had a contract with a large steel casting establishment to furnish 150,000 pounds of steel castings per month. The foundry, however, could deliver only half as much as it had agreed to, and finally, being pushed for the work, he started out in search of a foundry which would do better. He was prepared to place a contract for 300,000 pounds of steel castings to be delivered 75,000 pounds per month, and naturally thought that a man prepared to place such a contract would receive some consideration, an opinion based, of course, on previous experience in similar lines. The first place he stopped at was a large establishment in which, after considering the matter rather calmly and indifferently, they proposed to make his castings if he desired them to do so, but on making the price their figures were found to be more than four times the price he was already paying. He remonstrated with them about this and called their attention to the fact that the castings were not small ones, but were large and of heavy section. They said they knew all about that and understood it thoroughly, but that that was their price and they would make no concessions. Finally, when our friend was informed that no deliveries could be made within five or six weeks after receipt of order, he left to go to another place. This was a

smaller establishment which was just getting into shape for doing work. This concern had previously sent him a letter, asking for blue prints and specifications of steel castings that might be desired, and he thought that surely here he would find people anxious to take his contract. He found them not fully organized, and with only about a day's supply of pig metal on hand suitable for his work, and with no positive assurance as to where any further supplies of it were to come from. On going into the office he discovered evidence that duplicates of the letter he had himself received had probably been sent to about all the other steel casting users, this evidence being in the shape of an imposing pile of blue prints and specifications on the manager's desk, showing that everybody using steel castings had probably jumped at this apparent chance for getting some of them. There was no prospect of doing anything here. At the third place he visited he was greeted by a face which appeared at a pigeon hole, and in answer to his inquiry stated that they wanted no more business for the next eight months at any price or on any terms. Two other concerns panned out to about the same result, and the final conclusion of our friend was that the people who were already giving him 75,000 pounds of steel castings per month on a contract calling for 150,000 pounds were doing pretty well. By vigorous talk to them regarding what arrangements he might make with other foundries if he only chose to, he extorted a promise from them that they would do better.

IRON TRADE REVIEW.

In its issue of Aug. 10, this journal has the following on "The Position of Cast Iron":

Will steel eventually replace cast iron to such an extent that our iron foundries must be remodeled, or have their production greatly curtailed? This question is at present confronting many a concern about to increase its capacity, or to branch out into the casting business. This condition of the market to-day, while keeping every foundry busy, makes the greatest demand upon the steel casting trade. We know of a number of concerns which

are far behind in deliveries simply because they cannot get their steel castings. The manager of one of the largest manufacturing corporations of the country recently made a special trip to see for himself what chances there were for getting work done at the various steel foundries of the East and middle West. He returned greatly discouraged with the prospect, and engaged to fill up any new enterprise which would do good work at short notice.

Naturally this state of affairs means new steel foundries and a review of the situation finds them springing up at new points, while the gray iron foundries are contenting themselves more by working overtime and cautious enlargement than by an aggressive campaign. From the standpoint of the present demands it would seem that in the coming struggle, when prices go back to normal figures, the steel casting will be found more formidable to the gray iron foundry than it was at the last period of prosperity. This in spite of the necessarily greater price of steel, due to the use of high grade raw material and heavy losses due to process.

Is steel replacing cast iron as much as it is made to appear? Is the enormous demand for steel castings due to the removal of patterns from the iron foundries? More than likely the renewed activity of the country has enabled engineers to make use of an excellent material to a greater extent than ever before; and construction, which must be based upon light, strong and uniformly reliable products will make cast steel invaluable. Cast iron, on the other hand, with its rigidity and comparative cheapness, is not pushed out so easily. Only where consumers have been taught to distrust it, where the requirements of the case have made steel and malleable castings better adapted in spite of the increased cost, has cast iron yielded to the inevitable; and gray iron foundries have tried, and are still trying, to keep this down to a minimum. The foundry should keep on making improvements, and thus be abreast of competing trades. Then let it come to the survival of the fittest.

A closer examination of the characteristics of the material

may give us a fair idea as to the probable future of cast iron and cast steel. The former has a granular structure. The grains, so called, are all cushioned with graphite, easily separated from each other by a direct pull, but able to resist a tremendous crushing force without much deformation. Steel on the other hand is an aggregation of distinct crystals, the strong adhesive forces allowing a considerable flow of metal when a specimen is stretched, this also happening when it is crushed. Cast steel is especially valuable, therefore, when in tension, while cast iron is best adapted for compressive purposes.

From time immemorial cast iron has not given satisfaction when subjected to sudden and severe tensile strains; steel therefore took its place as soon as made reliable enough. The foundry business, however, has long ago adjusted itself to this requirement and has given up the gun though still keeping the mortar. On the other hand, we may go to-day into the rolling mills and ask there for the best roll for all around excellence, and we find not the steel, but the cast iron one recommended. Take an engine cylinder, whether it be as high as a small house or only for five horse-power; no one would think of casting it into steel. Here not only the rigidity, or lack of elasticity, but the fine-grained wearing surface make cast iron highly desirable. We question whether an engine frame would be made of steel were it as cheap as cast iron. And so all along the line we will find that whatever must be better than cast iron will leave the gray iron foundry, and that is no longer very much; and where work has gone out in the belief that steel will give commensurate returns for increased cost, study and improvement of the gray iron used may often bring it back.

Why is it that Americans prefer cast iron car wheels, while in Europe they are still forging them out of iron and steel? Only because our methods of mixing and casting good irons are acknowledged to be far ahead of theirs, being brought about by the kind of competition which not only cheapens, but improves the product.

Is it not perhaps this fear on the part of the founder that cast steel may supersede his gray iron that has developed the im-

portant foundry movement now quietly but surely working out its destiny? Has not the need of more light on the constitution of that mysterious substance, cast iron, been forced upon the founder by this fear of the future? He wishes to arm himself for a possible struggle for existence; and surely with so many bright minds engaged in helping him, he should be in a position to overcome eventually every difficulty chargeable to defective foundry practice, and have his metal in that place in the industry where it rightly belongs. It will be his own fault if he does not keep it there.

In the same number some "Notes on Malleable Castings" are contributed by "Low Silicon," referring to an article on the same subject which appeared in the Iron Trade Review, July 13, the author being E. C. Wheeler. The latter article was reprinted in the August issue of the Journal of this Association, see page 60. "Low Silicon" writes as follows:

The making of malleable castings has always been conducted on very secretive principles, and very rightly so, for the men in the works who made them were not giving away their claims to good salaries, and the owners who sold them certainly would not encourage competition. So between the two an important industry is to-day carried along on lines which make those who know how things are being run and how they should be, quite satisfied to gather in the dollars until the inevitable awakening comes.

The specifications given by Mr. Wheeler, while undoubtedly correct, are accompanied by deductions calculated on account of their lack of simplicity to deter the malleable man from employing the chemist in his work, though the author doubtless intended the opposite. A little running comment may therefore not come amiss in showing that the subject is not so difficult as it is generally supposed to be.

If it is stated that charcoal has never lost its position in the malleable foundry, it may be replied that the greatest and best malleable works of to-day are either using coke iron entirely or keep only a few piles of charcoal iron in their yard. Possibly this is for the benefit of stray customers who insist on its being

in their castings. So far as is known there has never been a lack of offers of charcoal iron at the works either, but knowing how to use coke irons properly, there seems to be no need of paying the extra price.

The use of chemistry for governing mixtures is not old, but those very few firms who depended upon it regularly during the lean years now happily behind the trade for awhile, were able to spend money for improvements, while most of the others had a hard road to travel. Fortunately for the foundry foreman the "malleable" pig irons are comparatively low in silicon and therefore easy to grade by fracture; the small charcoal pig especially shows up the range from 1 to 6 in a characteristic manner. That this grading is reliable must, however, be very much disputed, for the No. 2 of one furnace is the No. 4 of another, so far as an equal silicon content would have it, and a No. 4-H which analyzed the same as a No. 6 H, from the same furnace explains why some malleable works carry so much pig iron in stock and have to shut down occasionally to remove castings and sprues to begin all over again with new irons.

If to-day any malleable works stock up and use 5's and 6's regularly in their mixtures they had better call in a metallurgist expert in this line to save them money. The blast furnaces as run to-day are far ahead in method, of what they were 40 years ago. An immense amount has been learned in regard to regulating and cheapening the product, but very little in improving it. Everything to-day is for large output and where, as in making steel, any undue physical and chemical objections, sulphur effects alone excepted, can be readily corrected, and the improvements in furnace practice seem truly remarkable; but for foundry and especially malleable requirements this is not so noticeable at all. On the contrary, there are very good irons and some bad ones of the same composition, just as much in charcoal as in coke practice now as 40 years ago. The old days of cold blast charcoal iron, which iron has never been surpassed with all the improvements made, are fast going by. Whatever charcoal iron is still used in the malleable business is warm blast, and perhaps

the weakest iron may correspond to the warmest blast. Coke irons have their difficulties also. A good "coke malleable" is not outranked by charcoal so far as results show it, but a bad coke iron is to be avoided at all hazards.

With a given style of furnace, the same dimensions of every part of it including the stack, any number of them when starting off new will work practically alike. It is when the flues become choked, bottoms in bad repair and the whole furnace gets dilapidated that it must be fed with different mixtures to stave off as long as possible the time for a general repair or rebuilding. In this way a large works may have half a dozen mixtures running at the same time, but the end result should nevertheless be the same. To make a furnace last as long as possible, and yet get good castings is a part of every day economy which can only be arrived at by knowing exactly when to do.

In spite of the species of "higher criticism" directed against silicon as a basis of foundry mixtures, the advocates of graphite would be nowhere if they tried it on "malleable." The mistake is often made that the blast furnace by furnishing an iron high in graphite or high in combined carbon will enable the founder to reproduce this in remelting. To specify any carbon or form of carbon for "malleable" is a waste of time, for the carbon point below which it is impossible to anneal is well defined and never reached even by the amount of steel it is possible to add satisfactorily to the mixtures. The form the carbon takes in the hard casting depends entirely upon the silicon contents and the casting temperature. To narrow this down still further, the carbon condition may be said, when the proper amount of silicon is present, to depend only upon the casting temperature; and here those interested may have a direct proof. Take a quickly made heat, dip out from the top of the bath enough iron to make a fairly heavy sectioned casting. Do this at the same time that the heat is tapped, and pour the first iron into a similar casting. The first will be white and the last nearly gray. The silicon of both castings will or should be identical, yet the difference in temperature between top and bottom of the bath is sufficient to make a good

iron of the first and a failure of the last. Here, then, is "high" and "low" iron in the same heat, and the wise man pours the first of the top into light work and the end of the heat into the heaviest castings.

Now the above phenomenon is observed whether the phosphorus is nothing or .300 per cent; the manganese nothing or 1 per cent; the sulphur .005 or .07 per cent. There is consequently no special need to worry about the latent heat of these ingredients provided the silicon is right and the metal is hot enough to pour into castings of the heaviest sections common to "malleable" and leave them with but very little mottling. That a variation in the impurities produces marked results in the strength of the annealed casting is but natural, but so far as obtaining ordinary work is concerned, only an excess of sulphur and possibly phosphorus need be dreaded when the carbon in the hard casting was all combined.

The annealing process does not remove any carbon from the interior of the casting at all, nor does it change the combined carbon to graphite. Hardly an appreciable amount of silicon, manganese, or sulphur is removed either in the operation, unless possibly the annealing heat is raised far above that required. The temperature of the anneal is sufficient, however, to break up the rich carbon iron compounds, or rather solutions, and the excess carbon is thrown out and as it were deposited between the rounded crystals of steel remaining. This carbon is not graphite, but of a soft and amorphous nature—probably lamp black—and any graphite which may be present in the annealed material was not likely there in the first place; the more ~~of~~ this the deeper the shades of rottenness resulting. Those who may be interested will find that a malleable casting, yes, even a piece of white "malleable" pig iron, may be annealed perfectly by packing it in an inert substance such as fire-clay or sand, and with a total exclusion of air.

Mr. Wheeler is to be commended for his strong advocacy of the study of heat conditions in malleable work, for with the specifications of pig iron he gives the heat conditions present have the greatest effect in the success or failure of the melt.

In a "Review of the Technical Press," Dr. Richard Moldenke makes the following comment upon a paper contributed by J. C. Mears to a recent issue of the Age of Steel on "Oxide of Iron in Cupola Practice," which is reproduced elsewhere in this issue of the Journal. Dr. Moldenke says:

That the presence of oxide of iron in cupola practice should be made the subject of a special paper is a sign of progress, for altogether too little attention is given as yet to a systematical weeding out of burnt material in charges destined for important castings. Attention is called to the action of rusty scrap in cutting down the silicon below the normal loss, and the difference between the cupola process, which should avoid oxide of iron as much as possible, and the puddling process, in which it is a necessary adjunct, is explained at length. There are a few points which might be added here by the reviewer. First of all there are two forms of oxide of iron to be dealt with—rust, and dissolved oxide if it may be designated thus. The first, if it really got into the iron, would be the ruin of many a foundry, for the piles of rusting iron and scrap seen occasionally make one judge that at least one-tenth is oxide of iron. This rust, while infusible in itself, will either unite with the sand present to form a silicide of iron, or else reduce to iron by contact with the coke, or with the silicon, manganese and carbon in the pig iron as it trickles down through the intensely hot fire. A very small portion, however, will get into the iron and weaken it. The second form, or dissolved oxide of iron, is the more dangerous form. This comes from the oxidizing action of prolonged heating. Burnt grate bars, annealing pots, etc., when melted up with good pig iron will ruin it. This dissolved oxide is not all reduced, for reduction is best effected before fusion in a shaft furnace—as in the blast furnace—and in the cupola the running iron has not time to get all the oxide into chemical union with its carbon or with that of the fuel. When this is the case—it is so theoretically, the oxide being in contact with the carbon, silicon and manganese in the burnt iron—the result would not be a rotten casting. It would then seem that it takes, first of all, time, and

then intense heat to obtain the perfect reduction of burnt iron to a good article, and for this reason it is possible to make good steel out of burnt material in the open-hearth process, and it is not possible to obtain similar results in the cupola. This question of intense heat is more important than it looks. All iron when liquid contains more or less gas. This is nearly all disengaged as it sets—the quicker the setting takes place the fewer are the evidences in the shape of blow holes, etc. Now the addition of aluminum or manganese takes away these gases (hydrogen, nitrogen and carbonic oxide) in steel, and even purifies it from much dissolved oxygen. In cast iron, however,, this is not as marked and solely for the reason that melted cast iron is some four or five hundred degrees colder than melted steel. The addition of ferro-manganese in car wheel mixtures, while good, is not as effective as could be wished, its benefits no doubt lying to some extent on the reaction with sulphur. On the whole here is a subject which will repay investigations more than any other line of research, for the founder of heavy castings which must have an absolutely clean surface and be very strong will find their greatest enemy in the dissolved oxide of iron either getting into their charges or formed during the melting operation.

AGE OF STEEL.

In a recent issue of this Journal, J. C. Mears has an article on "Oxide of Iron in Cupola Practice," in which he says:

The effect that oxide of iron, when added in a cupola, would have upon the mixture, depends upon the amount of oxide added —upon the mixture itself—and the construction of cupola. In ordinary cupola practice the oxide is to be avoided. When the cupola is high there may be a reducing action and some oxide reduced to iron. In this case there would be a small increase of iron, although some of the oxide may be reduced by the silicon of the iron, thus decreasing that ingredient. In the ordinary cupola the oxide is not reduced by the coke directly or indirectly. Some, perhaps, is reduced, as Prof. Turner and Gautier say in their articles on silicon in foundry practice.

Oxide of iron has a great tendency to attack, I might say, all the impurities of iron, meaning by impurities the carbon, silicon, manganese, sulphur, phosphorus, etc. Oxide of iron plays the most important part in metallurgy in making malleable iron, wrought iron, steel, etc. In some cases oxide is added as roll scales, iron ore, etc., but in very many cases it is formed by the air oxidizing the iron. In malleable the air passes over the iron and oxidizes the iron to oxide; this oxide acts upon the ingredients of the iron; upon the silicon and manganese first, then at a higher temperature upon the carbon. In malleable wrought iron, etc., we want to reduce these ingredients, but in a cupola we do not. In a furnace we have this oxide in contact with the iron a long time; we can stir it in the iron and then let the impurities rise. In the puddling furnace this oxide, at a lower temperature, attacks the silicon and this is slagged off, thus leaving a white iron high in carbon. This action of oxide upon molten iron is about the same in the cupola if it were in contact with iron long enough. Oxide of iron has a decided effect upon the casting, as it lowers the silicon. Wanting a given per cent of silicon in the casting, the mixture must be made higher in silicon if rusty scrap is used, than if it is not rusty. To use rusty scrap in order to bring down the silicon would be bad practice, as the mixture could be made lower in silicon to start on. While in the air furnace the body of iron lies quiet and all impurities rise to the surface, in a cupola this is not the case. In a cupola the iron runs out continually, or is tapped often, and there oxide does not have a chance to separate, but mixes more or less with the iron.

Here is the main trouble with oxide. The ladle contains some oxide; it acts upon the iron in the ladle and often makes the casting on the top side of mold full of small holes; hard spots are formed, and blow holes; blow holes with often a little, round shot-like iron at one side. The iron itself is rotten. Of course, I am presenting an extreme case, and these different signs will show up more or less, according to the amount of oxide present. In a cupola there is always more or less oxide present, and the more, the lower the silicon. To counteract this, we add in the

ladle, in the wheel foundry, some ferro-manganese. Most of this manganese is slagged off, combining with the impurities.

When melting old, burnt grate bars and the like, we have a great deal of oxide of iron. The iron melts and oxide remains. This acts upon the molten iron and reduces the silicon. Oxide of iron itself is, I might say, infusible—it is a base and wants to combine with something. Silica is an acid. Hence in a case of this kind, if sand is added, the oxide of iron forms a slag, and a more fusible slag, leaving cleaner iron. This is all there is to Mullen's silicated iron process, which made quite a stir for a while.

There is no advantage in adding sand to a grey iron mixture, unless a great deal of oxide of iron is present; then the sand helps to make a fusible slag. Silica or sand around the pig is an acid and combines with oxide of iron, lime stone, etc., to form a slag. To get rid of this sand, limestone is usually added. When limestone is not used, the silica must combine with some other base, and as there is none, it must combine with the oxide of iron. Where the oxidation of the iron by the blast forms enough oxide to combine with the sand to make a fusible slag, the slag runs off without lime.

Slags are of different kinds. They are classified according to the amount of silica to the amount of base, correctly, according to the amount of oxygen in each, and each has a different melting point. Now, whenever limestone is not used, the proportion of sand going into the cupola and the oxide of iron formed by the oxidation of the blast, may be such as to form a slag which is not easily fusible and which causes the cupola to work badly; while, if more oxide of iron were present, the slag would be more fusible and cupola work better, giving better satisfaction all round. In cases of this kind, rusty scrap would do good, and the foundry foreman would be led to believe that the addition of oxide was a good thing. It surely would be until the slag was fusible. It would, however, be a great deal better to see that less sand be added, and if that could not be done, it is far safer to add a little limestone. Besides, lime has a great affinity for sulphur.

While oxide of iron is the greatest substance known to purify iron of its ingredients, it must be used at the proper place and in the right way. In the cupola, it is surely out of place for ordinary practice and cannot be called a purifier, excepting in rare cases, as stated above, when limestone is not used and there is too much sand present.

THE FOUNDRY.

E. C. Wheeler contributes an article on "The Basic Furnace for Malleable Iron," which is reproduced herewith:

The question of producing a thoroughly uniform malleable casting is one of great moment, involving as it does many seemingly intricate problems, and the solution of which (by the ideas already advanced and constructions anticipated) it will be admitted is not very satisfactory. It is recognized that the cupola and reverberatory air furnace do not guarantee the metal wished for, and reasons for said deficiencies are known to all careful observers of their respective workings. The metal in a cupola being in direct association with the reductive agency, becomes an absorbent, and while in this condition impurities of the fuel are taken up by the metal. The metal in air furnaces having an oxidizing flame upon it, for continued periods, after being tapped does not allow the same physical characteristics to prevail throughout heat. In both of the above mentioned methods of reducing initial pig iron, there seems absolutely no chance for the elimination of the objectionable impurities, but rather the feature is presented of further increase. There is no bad or worthless pig metal, there is some place for it all. This statement must not be construed into meaning that malleable metal may be produced from any class or grade of iron, but that the metallic oxide of iron is as pure in a high No. 6 with its high portion of sulphur and a No. 1 foundry with its high phosphorus, as in the finest grades of Bessemer or open hearth pig irons. If some method were feasible whereby these lower irons might be freed from their troublesome burdens, it is believed that the road would be open, for their ready adoption into fields now closed on account of these impurities. There has been a movement in this

direction, and which, like all radical changes in foundry practice, has met with a great amount of criticism from those best situated to acknowledge the worth of same, and this has been the adoption of the Siemens-Martin type of acid open-hearth furnaces for malleable, by several very prominent concerns. This furnace and this idea have always raised a great cry in the malleable industry, just why this should be is not clear, for its productions have earned no small reputation. The metal, however, has not been advanced to such a degree of proficiency that the successful casting of small shapes has been accomplished, rather its field so far has been more in the line of heavy work casting. There have been many heats where the metal would have poured the very smallest shapes, but this, of course, has been the exception. Therefore, the field of progress in this direction is comparatively new, and yet, though in its infancy, its shortcomings are so pronounced and being with small chances for redemption, the casting world is alive, and anxious for the advent of a furnace which will combine its good qualities with some radical improvements for its poorer ones. A divergence of methods in any industry is accepted only after exhaustive experiment, for with all this present rush of business, and the ready money available, there is no great incentive offered, which would affect readily the conservatism prevailing in the malleable iron business of to-day.

The adoption of a basic lining and fluxes for either the air furnace or open-hearth furnace is advocated for the casting of all heavy railroad shapes, where the one great feature of uniformity is so prominent, and which do not require the maximum fluidity of metal. In foundries where the tonnage per day is from 60 to 100 tons, the open-hearth type of furnace ought to be accepted as most practical and economic. This furnace is not an experiment in the malleable business, there are many of them in use, and the idea is here presented to change same from the acid type to the basic. The advantages to the iron from a chemical and physical standpoint are only too apparent. It is the supposition that the dolomitic and magnestic lining and fluxes will so permeate the metal in bath that their influences will have no uncertain

or deleterious effects, rather the resulting product will possess every advantage claimed in this advancement of ideas. The acid type open-hearth as used for malleable to-day does not produce a metal which varies radically from the reverberatory air furnace product, excepting perhaps the one feature of its being lower in total carbon, and hence more malleable, and also, the reducing to a minimum of chance to absorb impurities from the fuel. The main advantage in this style of furnace has been the rapidity with which carbon may be combined, thus making it possible to pour castings of large diameters, avoiding all chances of same being mottled, and therefore weak. In the casting of draw-bars this is indeed a very essential point. A curious phenomenon, and about which is centered a great many doubts and surmises, is that when metal is finally annealed the carbon is in the graphitic form, same as original pig iron, and yet if this metal before annealing should contain appreciable quantities of graphitic carbon, the resulting metal would be worthless. This may be explained by reason of the fact that whenever graphitic carbon is in evidence it is always a controlling influence, preventing to a certainty the possibility of further chemical and molecular change.

This is true of the original pig iron as in matter of castings. Successful malleable iron can never be made when castings are gray or mottled in the "hard" iron. Gray iron castings when run through the malleable anneal are always burnt. There is nothing present to prevent this, as long as the carbon is in combination with the iron. There is absolutely no danger from firing, when the chemical and molecular change or transition has taken place in the metal, continued firing invariably burns or overanneals the metal. Very often metal is burnt in annealing in exactly this manner. In this proposed basic furnace, whether it be air or open-hearth types, the one great aim is to offer a metal which shall be consistently uniform, and all metallurgists will recognize the significance of this statement, that, in present constructions, this is not always possible, through the intervention of many destructive agencies. The cause for said defects have in turn been attributed to the effect of every metalloid con-

tained in pig iron, for in some localities the carbon has been too high, or excess of phosphorus has produced hardness, or again the sulphur has been high, manganese too low, or not enough silicon. When a doubt has arisen about the certain and absolute percentage of any alloy, concerning its effects for good and evil, the point of safety for same is generally reached only after exhaustive chemical research. But there is always a reasonable doubt that this very identical point has been established, through the aid of some other alloy, whose influence may not have been appreciated at the moment, and therefore not taken into account. If this is not so, why does irregularity in furnace working continue, after the factor of safety is known, and calculated for every heat?

It must be admitted by every thoughtful producer that it is simply a metallurgical impossibility for one concern to base all its faith in malleable upon a certain established limit, for example phosphorus, and another concern to hold strictly to silican, or sulphur or manganese, and, disregarding all other companion metalloids, offer the same class of material to consumers. That different concerns following divergent lines in working, produce successful material is a fact, but the reasoning of same is immediately negative, for they are reaching their conclusions by the disregard of some dominant associate influence, without being aware of its prominence, and effects. This must be a patent truth. It is often said that no two furnaces work exactly alike, but this is purely and simply a heat condition, and no reasonable deduction that a radically different chemical formulae is required. Must we retrograde to the days when chemistry was an unknown quantity in the malleable industry, and when furnaces were charged with No. 1 iron, and tapped only when iron showed white? Without the aid of chemistry the pioneers in the malleable trusted to a natural course of evolution in the metal to accomplish their desired ends, and how well their expectations were realized is a matter of history. The malleable industry has assuredly made great strides since those days, and it is as yet very young in the business. This latter is very prominent by the lack

of literature on the subject. In its companion metal, steel, there is not the slightest deviation in chemical ideas and formulae, if methods vary, it is only so because of the differing local constructions. The practice is universal. It is following these above mentioned facts that the basic furnace seems a possible outcome for the future, to manufacture as nearly as is practicable a chemically pure iron, which after annealing will not allow of the many changing aspects of the modern metal. The loss (by absorption) of the impurities cannot but make the iron that soft, pliable metal so eagerly wished for. The physical properties will be enhanced greatly, for the iron will have shaken off its parasites, and, being free, will no doubt find many markets opened, which to-day are closed on account of the uncertainty regarding succeeding heats. In considering the question of uniformity the fact must be faced that, in any of the casting industries metal to be strictly alike throughout a heat, must be removed from furnace influences in bulk. In a few words, the metal must be tapped into some large receptacle, away from all possible chance of further chemical and molecular actions. In a Siemens-Martin acid open-hearth, which it was the privilege of writer to operate for some little time, malleable iron of great uniformity and ductility was produced. The metal was handled in a rather unique way, owing to the fact that peculiar conditions existed making it impossible for the molders to catch iron at furnace spout in the usual manner.

The metal had to be carried about 200 feet before reaching the molders' floors. The method which suggested itself was to tap the entire heat into a ladle attached to an overhead traveling crane, and when the molders' floors were reached, the ladle was tipped and its contents poured into small ladles. The experiment was tried of pouring from the bottom of ladle, but this way of tapping from bottom allowed the top to chill, to such a degree, that skulls were frequent and annoying. Tipping the ladle and allowing all metal to come from top, maintained the metal the same heat throughout. The one prominent feature was that this metal was uniform, and whether the initial mixture was all that could have been desired might be a matter of opinion, but the

resulting metal, whether or no, was the same all throughout. The shrinkage was very uniform. This method of handling was therefore a great success from one point of view, for it was possible to produce a consistent metal as regards the heat conditions during pouring, and subsequent cooling, although it did not present any radical advantages over the reverberatory metal, with peculiar reference to the elimination of deleterious metalloids. They were all there, and in the same quantities. The qustion naturally arises that if this Siemens-Martin furnace had the prepared lining and fluxes of the basic methods, whether the metal would not have had all the advantages herewith claimed. The claim is here made that malleable castings produced under basic conditions will anneal in three days' firing, and will contain many essential features now lacking in present methods. It is possible to refine pig iron to any degree desired if the selling price will warrant the outlay, but it is not possible to so influence the native ore, charged into blast furnace, that after the burden has passed the fusion zone, and the iron has dropped to the hearth, that the metal will be a strictly desirable article. Many ores are roasted before charging to remove the sulphur, but the other impurities remain. Pig iron as cast is most uneven in quality, succeeding casts vary and it is no wonder that difficulty is experienced in the casting arts to produce uniform metal. If pig iron were freed from its harmful agencies, it is believed that the casting art would be advanced fully 50 per cent. We hear from all sides of the harmful effects of this or that metalloid, that phosphorus "hardens," sulphur "shortens," manganese "stiffens," silican and carbon working together in certain ratios affects the physical strength. If these elements were removed, the iron would in a great degree develop qualities now latent, through lack of opportunity to expand. Blast furnace, and remelting or refining methods have not reached their limits by any means, but there does seem to exist a lull in their advancement, and at a time, too, when a change would seem from a buyer's standpoint most opportune. With a basic furnace for malleable, would come a revelation as to the metal's possibilities. If the basic

idea should be entertained with any degree of encouragement by malleable concerns in general, there would be possible a great change in foundry construction, which would remove from foundry interiors all melting furnaces, as the latter could be erected outside buildings, with only tapping spouts projecting through the walls.

The metal could be tapped into previously heated ladles of a size sufficient to contain a whole heat. These ladles would run upon tracks parallel with furnaces. After tapping, which would take, for 8 or 10-ton heat, about two minutes, the chargers would start immediately to recharge furnace, and same would be on its way remelting before previous heat was all poured. If a concern was melting 60 to 100 ton of metal per day and each furnace was melting three heats, there would be a furnace gain in melting of 45 minutes per heat, or 2¼ hours per day, which would go a very considerable distance toward melting third heat, during a working day of 10 hours. With a basic open-hearth a 10-ton heat may be charged in fifteen minutes. This has been frequently accomplished, and the apparatus at hand was not of the very advanced construction either. This proposed method of handling the whole heat in one ladle is nothing new, therefore no experiment; and it is thoroughly practical.

A correspondent writes that the best way to melt steel or wrought iron turnings is to put them into the crane ladle, in the proportion of from 12 to 20 per cent of the capacity of the ladle and then tapping good hot iron upon them. By this method he will avoid bunging the cupola, and will lose none of his metal by evaporation, as he would be likely to do if he melted wrought iron turnings in the cupola.

Where I learned my trade, steel turnings were always used in this way to cast hammers and blocks for the forge. These blocks as they wore out were melted in a reverberatory furnace and cast into pigs; the pigs being afterwards used with about 30 per cent of Scotch pig to cast cylinders and other castings requiring the best quality of iron.

Paul R. Ramp contributes an illustrated article on "Venting."

W. H. Kane writes an article in which he contends that the practical foundryman should have complete charge of the foundry and that the authority of chemist should not in any way be made to conflict with the foreman's duties.

W. Roxburgh writes of chaplets and how they should be treated before using.

R. D. Moore advances some theories regarding the "Pressure of Liquid Iron" supplemented by his own personal observations.

Eli H. Pearce describes "Some Points in Melting," showing that one way of obtaining a low quality of castings even when using the best of iron is owing to a poor blast. The writer recommends the use of a blast guage to guard against such occurrences. Mr. Pearce concludes: "Another way to convert good pig into hard iron in a small cupola is by charging too much at a time. We have two cupolas, one 30 inches and one 20 inches in diameter. We can charge 1,000 pounds pig in the 30-inch and make soft iron, while in the 20-inch we can only charge 200 pounds pig, using the same proportion of coke to iron in each case. The explanation of this is that in the 30-inch cupola the iron sinks down gradually and does not hang, while in the 20-inch it is easily jammed and hangs until the bed is burned out, then when it does drop it comes into contact with the blast and is hardened.

Twenty inches is rather small for a cupola, but it is a very handy size to have in a jobbing shop, where it is often desirable to melt about 1,000 pounds for a heat. In a case of that kind the saving in coke and convenience of a small cupola is enough to make a fellow feel glad that he has one.

In writing of "Porosity and Shrinkage of Brass Castings," Mr. C. Vickers says: "The more rapidly a brass casting is cooled, the smaller will be the crystals, so it will present a dense solid appearance; the slower it is cooled the larger the crystals. The metal in contact with the damp sand of the mold is quickly chilled. This forms a skin, and to this skin the metal, as it cools and crystallizes, attaches itself; the crystals becoming larger as they are nearer the center of the casting, because the cooling

is slower, as the heat has to pass through a continually increasing thickness of hot metal. Now if cope and drag are of the same depth, the top and bottom skins will cool with equal rapidity and divide the available metal between them. As the metal crystallizes or solidifies it shrinks in volume. Consequently, if the casting is not supplied with metal to make good this shrinkage from some source outside of itself, there is going to be a flaw or cavity in the same. In the case of thin castings, the top crust cools so rapidly as to be able to sustain its own weight, and the casting is of the same thickness as the pattern. It ought to be thinner by the amount of the known shrinkage, which is just sufficient to cause cracking or separation. A casting that is solid will have cooled more uniformly, the metal will have settled, making the casting thinner than the pattern. The writer would suggest that the metal be thoroughly mixed by stirring, and be poured as cool as possible where cracking or shrinkage occurs.

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Writing of explosions which sometimes occur in dropping the bottom of a cupola, E. H. Putnam says:

"In dropping a cupola bottom if the large mass of hot coke, slag, cinder and pieces of white-hot iron fall suddenly upon a wet base, an explosion is inevitable; and the danger and force of the explosion is greatly increased if there happen to be a considerable quantity of melted iron present.

Under no circumstances should the bottom be dropped until it is known that practically all the melted iron has been drawn out. Cinders will lie up loosely upon the sand base, and will not, except under extraordinary circumstances, cause an explosion. If a large mass of these, in a semi-plastic state, fall upon a wet base, and be forced down into it, an explosion is certain. But this does not often happen. Melted iron, however, will instantly find its way to the bottom and if this be wet, it will be heard from instantly.

It is not always possible to know whether there is molten iron in the cupola or not. There may be a depression somewhere

in the sand bottom of the cupola, which will contain a considerable quantity of iron that will not run out at the tap hole. Again, the tap hole is sometimes so mismanaged as to raise it somewhat above the level of the bottom before the end of a heat. In this case the breast of the cupola ought to be entirely torn away in order to make sure of withdrawing all of the iron.

However, though it may be impossible to be certain that all of the melted iron is out, it is always possible to have a large body of dry sand under the cupola, and it is impossible that an explosion should occur where there is no moisture.

When one of these explosions occurs the man who is directly responsible for it is very glad to have all sorts of mysterious causes ascribed, and when the true cause is named he will sometimes stoutly deny that there was any wetness under the cupola, and it is, of course, a very difficult matter to determine the case after the damage has been done.

From this fact some people are led to believe that somehow a peculiar and unusual combination of gases was at fault. So extremely improbable is this hypothesis that it can have not the remotest claim to recognition except upon positive proof of the absence of moisture.

In short, if a good, deep bed of dry sand is under the cupola, and practically all the melted iron has been tapped out when the bottom is dropped, there will be no exeplosion.

The same author answers a question regarding the advisability of starting the manufacture of malleable castings on a small scale, as follows:

The chief difficulty in the malleable iron business is in marketing the product. And even this feature is not operative at the present time; for the demand is in excess of the supply. The question is: Will it pay a firm that uses a large tonnage of malleables to install a plant and manufacture them? The answer depends upon the class of goods wanted, and the amount to be consumed. If the product is heavy, like, for instance, car couplers, requiring the greatest possible strength, the iron must be melted in the reverberatory furnace; and with this system economy of production requires that three heats a day be melted, amounting to at least 15,000 pounds. And this woud have to be kept up for a considerable period of time, because the first few heats would be sure to cost more than the market price

of the product; indeed, if the business were placed on a paying basis within two or three months' time it would be quite exceptional.

But, if the class of product required is such as is used for general agricultural and similar machinery, wherein good malleable are quite as serviceable as the best, the case would be very different.

In the second instance, the cupola would be just as efficient for melting the iron as the reverberatory furnace. Twenty-five years ago excellent malleables were made of cupola iron, and even to-day much of the light malleable is cupola product. It should be borne in mind also that knowledge of iron chemistry is now very far advanced from what it was twenty-five years ago. Then, and even at a much later period, the iron from certain districts, or from some particular blast furnace was supposed to be all right for the purpose, and it was not at all common to refer to chemical analysis. The iron had to be of the charcoal brand, and of such grade (judged wholly by fracture), as to insure total combination of the carbon in the casting in product. If good malleables were customarily made under these conditions, how much better must be the product to-day, since we have learned the exact chemical content required, and have but to specify in order to get from the blast furnace just what is wanted..

Where malleable castings are manufactured on a large scale, a chemist, or analyst may be employed at the foundry with profit. But the analysis furnished by the blast furnace, where the standardized drillings furnished by the American Foundrymen's Association's Bureau is reliable, and if this is taken advantage of re-analysis is unnecessary.

In order, then, to add the manufacture of malleable castings to any iron foundry business, it is simply necessary to build annealing ovens, and to employ a superintendent who knows how to do the business. The former is a mere mechanical operation that can be performed anywhere and at any time. As to the latter, if you cannot find a suitable man who you are sure knows how, why, you had better make a present of your surplus capital to some deserving charity; you get rid of it a little more quickly, but not more surely.

The man who is to superintend the malleable department should be a thoroughly practical founder, in grey iron as well as in malleable, and thus the cost of superintendence would not increase beyond due proportion to the increased product.

Assuming then that you have a superintendent who understands the whole business, including grey, and malleable iron founding, and the annealing processes, and an annealing oven, the latter at a cost of about $1,000, you will be ready to go into the manufacture of malleable castings.

No extra cupola will be required, as the iron for malleable castings will be melted at one and the same heat with the grey iron.

In manufacturing malleables on a small scale, the cupola affords very great advantages over the reverberatory furnace; for, in conjunction with the grey iron, you can melt a heat of one thousand pounds of iron for malleables at practically no greater proportionate cost than if you were to melt ten thousand pounds or more. This would give a product not to exceed five hundred pounds of malleable castings; for, at least half of this would be run into annealing pots, sprues and "over iron;" that is, surplus iron, that always attends the casting process. It will be seen, therefore, that a very small business in malleable iron can be conducted in conjunction with grey iron founding without much extra cost.

To reduce any kind of business to the greatest economy it is necessary that it be continuous, so that all hands may become accustomed to the work, and thus, what was difficult at the outset, will come to be easy and simple and errors of to-day will be corrected to-morrow, a thing that, for obvious reasons, would be impossible, if long periods of time were to intervene between operations. The same molders who do the grey iron molding would, in many cases, do the malleable iron molding also; so that, in course of a few weeks, the foundry department would be running as smoothly as before the malleable business was added.

The annealing process cannot be conducted as economically on a small scale as on a large one, the principal difference being simply in the cost of heating the annealing ovens. It requires, say, two day's firing to get the heat of an oven full of castings up to the annealing point. In large concerns, when the annealing process is completed, the oven is emptied and refilled at once, and so, the heat that remains in the brick work of the oven is utilized. But this saving, divided into 24,000 pounds of castings, would not amount to very much per pound.

To conclude, I should say that the firm that uses at least two hundred tons of malleable castings a year can make them more profitably than they can buy them—if it knows how.